

## Consequences of Aluminium Smelting on Air Quality in Ikot Abasi I.G.A., Akwa Ibom State South-South Nigeria

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### Abstract

The study identifies and examines air pollutants in the Aluminium Smelting Company of Nigeria, ALSCON. Field investigation and laboratory experiment of air samples collected from the study area was carried out following wind direction. The results of the air samples gotten after laboratory analysis were compared with the Maximum Acceptable Concentration (MAC), provided by Federal Environmental Protection Agency (FEPA). The result however shows that the concentration of  $\text{CO}_2$  and  $\text{CO}$  was high within the study area. The study reveals that there were traces of  $\text{SO}_2$  and  $\text{NO}_2$  gases in the air around the study area. From the findings, it was very obvious that the activities of ALSCON are seriously affecting the air quality of the study area, this has resulted in the change of coloration of the vegetation around the area. The student's t-test was used to test the hypothesis, and the result shows that there was a significant difference between the air quality of the area and MAC by FEPA. Therefore, the reduction of the volume of pollutants emitted into the atmosphere, would served as a strategy to mitigate the effects of these pollutants on the environment.

### 1. Introduction

Under the Clean Air Act Environmental Protection Agency (EPA) is required to regulate of 188 listed toxins. On July 16, 1992, EPA published a list of industry groups (known as source categories) that emit one or more of these air toxins. For listed categories of "major" sources (those that emit 10 tons/year or more of a listed pollutant or 25 tons/year or more of a combination of a listed pollutant), the Clean Air Act requires EPA to develop standards that require application of Maximum Achievable Control Technology (MACT) to control emissions.

The World Bank Report of (2001) places aluminium smelting as a major air pollutant in the nearest future. Aluminium is the most flexible metal ever and is used in a variety of industries and at home too. Unfortunately, aluminum has been discovered only in the last 150 years, even though the Chinese have used it since the year 300 AD (Brower, 2010). Aluminum has a direct impact on 60% of the world's economy (Garry, 2010). The chemical composition of standard air includes three (3) major gases and other smaller gases. The three major gases are; Nitrogen (78%), Oxygen 21% and argon (1%). These three gases make up 99.96% of standard air. The remaining 0.04% contains small amount of neon, helium krypton, hydrogen, and xenon even water vapour is also present. Increase of any of these gases or the introduction of a gas into the atmosphere will then result to the pollution of the atmosphere resulting or the reduction of air quality. In the environment where aluminium is smelted there is a possible introduction of gases into the atmosphere, such as fluoride, sulphurdioxide, such as fluoride, sulphurdioxide and carbon dioxide. All these gases reduce the quality of air in areas where it is introduced into the atmosphere.

Potentially, the mining and smelting of aluminium can have major environmental impact. Aluminium is an abundant metallic element which is widely used throughout the world for a range of products (Smith 2009). It is the third most abundant element, only oxygen and silicon are present in greater amount. Aluminium is found on the earth crust and it becomes a resource after processing from the ore to materials used in our day-to-day activities.

In the process of mining, open cuts may be left unrehabilitated or unrestored leaving the vegetation destroyed, the genetic soil profile displaced, wildlife and habitat destroyed, degradation of air quality, alteration of land use and the general change in topography. During smelting, red mud disposal areas are left unvegetated and emission from pot line may not be passed through the scrubbing system therefore allowing gases such as fluoride carbondioxide and dust particles to dissolve into the atmosphere and consequently polluting the air.

The aluminium smelting company of Nigeria (ALSCON) only processes alumina to ingot and during this process some pollutants such as carbondioxide, fluoride and some particle matter may escape into the atmosphere. Though the company has an environmental protection unit but simply betrayed by the evidence of the yellow grasses and leaves of trees. The rest of the paper is divided into three parts, materials and methods, pollution associated with aluminium smelting and discussion of findings.

## **2. Materials and methods**

Field investigation and experimental method was employed in this study. Air quality analysis of the immediate air emissions were sampled and the dust particles and potentiometric method for the fluoride, carbondioxide and other elements that can be found in the air.

The samples collected from the field were taken to the laboratory where the use of "ion selective metre" provided the statistical data used for analysis.

### *2.1 Instruments*

The impinge train with the deionized water was used for sampling the level of pollutants present in the sampled air. The train is connected to a vacuum. The ion selective metre, an Orion and the spectrophotometer for reading the levels of the contaminant. The dust sample, was also used to sample the particulate in the air and the gravikon ve 25.

## **3. Pollution associated with aluminium smelting**

Air emissions come from a number of sources. The grinding of the bauxite, calculating the aluminium oxide, the handling materials produce particulates. During the primary processes air can be emitted into the atmosphere during the reduction of aluminium oxide to aluminium metal. In the secondary process of aluminium smelting, air emission depend largely on the quality of scrap used. Emission can come from smelting, refining and the furnace effluent gases. Air emission and solid-phase waste are the primary concerns in the aluminium processing industry.

Solid-phase waste from secondary aluminium production is slag formed during smelting. The slag contains chlorides, fluxes and magnesium. Liquid wastes include water that is added to the slag to help separate the different metals. The waste may be contaminated with salt and fluxes, but can often be recovered and reused. Liquid is not a great concern in aluminium process, so is solid phase waste. Since it is well known that the most form of pollution from aluminium smelting is from the emission of gasses therefore; the different gases emitted and how aluminium smelting companies try to reduce them will be discussed.

### **Fluorides**

Fluoride is the anion F<sup>-</sup>, the reduced form of fluorine. Both organic and inorganic compounds containing the element fluorine are sometimes called fluorides. Fluoride like other halides, is a monovalent ion (-1 charges).

Fluoride, is released into the air when fluoride containing minerals are heated to high temperature, once its in the atmosphere, it is washed into the earth surface through rain and is neutralized to form inorganic fluoride salts. The fluoride ion is highly toxic to living organisms.

Most smelters have scrubbing equipment which removes up to 99% of all emission from the pot IAI (2009). The materials removed by scrubbing equipment can then be re-used in the smelting process. As a result current average levels of emission of fluoride to the atmosphere are as low as 1kg (0.5kg) for the new modern plants of fluoride per tonne of aluminium IAI (2009).

### **Sulphurdioxide**

This is generated from the sulphur contents at fossil-fueled power stations and from other parts of aluminium production process – steam generation in alumina plants. Ovens in anode plants and anode consumption in the pots. Wet scrubbers are used to remove the particles of sulphurdioxide from the air. Sulphurdioxide is generated in very minute quantity that its effects are not seen by aluminium smelters.

## Carbondioxide

Carbondioxide is a feature of all metal processing producing company that produces metal by electrolysis from ores containing oxides. This gas is formed when the carbon in the anode combines with the oxygen in aluminium oxide during the smelting process. It is therefore an un-avoidable by product of the aluminium smelting process. Over the past 10 years the aluminium industry has reduce its carbondioxide output by around 10% through the development and use of better production techniques.

### 4. Discussion of Findings

The aluminium producing environment has over the years been known for certain pollutants, which may have major environmental impact. During smelting, emission from pot room may not be passed through the scrubbing system or the treatment plant, therefore allowing pollutants such as fluoride, carbondioxide, carbon monoxide, aerosols, sulphurdioxide and nitrogenoxide to dissolve into the atmosphere and consequently pollute the air.

**Table 1:** Showing air quality in alscon location A (The Pot Room)

Location	Distance from location	Volume of fluoride (mg/m <sup>3</sup> )	Volume of aerosole (mg/m <sup>3</sup> )	Volume of carbonmon oxide (mg/m <sup>3</sup> )	Volume of Carbondioxi de (mg/m <sup>3</sup> )	Volume of sulphurdioxid e (mg/m <sup>3</sup> )	Volume of Nitrogenoioxid e (mg/m <sup>3</sup> )
A <sub>1</sub>	500m	1.000008	0.0026	129.01	1276.8	8.379	12.103
A <sub>2</sub>	800m	0.0096	0.0016	95.76	997.5	5.985	8.379
A <sub>3</sub>	110m	0.0062	0.0008	29.26	931	4.123	4.655
A <sub>4</sub>	1400m	0.0031	0.0003	22.61	904.4	3.857	2.793
Total volume of Gases (EA)		0.0189	0.0053	276.64	4109.7	22.344	27.93
Average volume of gases (EA ÷ 4)		0.0047	0.0013	69.16		5.586	6.9825

Location A (Table 1) is where the pot room is found and this is where the production of aluminium takes place. Emission of gases is high around the area. Some gases are even above the maximum allowed concentration (MAC) as stipulated by the Federal Environmental Protection Agency (FEPA). Though gases are sent through the fume treatment plant for purification but some gases still manage to escape into the atmosphere.

During data collection, it's was observed that samples of air gotten from this area had the highest volume of gases suspended in the atmosphere. This could be as a result of the activities in the pot room and the fact that fumes are expelled towards the direction (i.e. location A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>, A<sub>4</sub>).

In table 1 and graphical representation below shows comparism of the maximum allowed concentration of the air quality analysis gotten in the first location.

**Table 2:** Comparism table of the air quality result at location A and Mac by FEPA

Pollution/units of	Maximum allowed	Air quality analysis
Fluoride (mg/m <sup>3</sup> )	0.003	0.0047
Aerosole (mg/m <sup>3</sup> )	1.5	0.0013
Carbonmonoxide (mg/m <sup>3</sup> )	66.5	69.16
Carbondioxide (mg/m <sup>3</sup> )	665	1028.09
Sulphurdioxide (mg/m <sup>3</sup> )	5.32	5.586
Nitrogendioxide (mg/m <sup>3</sup> )	6.65	6.9825

Based on table 2 above, it was observed that four out of the six analyzed gases exceeded their maximum allowed concentration recommended by the Federal Environmental Protection Agency of 2005. The air quality in this area are carbonmonoxide, carbondioxide, sulphurdioxide and nitrogendioxide. Fluoride which is usually the most emitted and most dangerous pollutant produced by aluminium smelters, was then found at a considerably low volume. This may be due to the fume treatment plant and the consciousness of the company to reduce fluoride emission to the bearest minimum.

**Table 3:** Showing air quality in alscon location B (carbon room)

Location	Distance from location	Volume of fluoride (mg/m <sup>3</sup> )	Volume of aerosole (mg/m <sup>3</sup> )	Volume of carbonmonoxide (mg/m <sup>3</sup> )	Volume of carbondioxide (mg/m <sup>3</sup> )	Volume of sulphurdioxide (mg/m <sup>3</sup> )	Volume of Nitrogenoioxide (mg/m <sup>3</sup> )
B <sub>1</sub>	500m	0.0043	0.00005	93.1	957.6	7.847	5.32
B <sub>2</sub>	800m	0.032	0.00002	83.79	837.9	5.453	5.32
B <sub>3</sub>	110m	0.0021	0.000009	5.187	691.6	3.724	3.99
B <sub>4</sub>	1400m	0.0019	0.000006	37.24	585.2	2.926	2.66
Total volume of Gases (EA)		0.0115	0.000085	266	3138.8	19.95	17.29
Average volume of gases (EA ÷ 4)		0.0029	0.000021	66.5	784.7	4.988	4.3225

The second location where samples were collected is called the carbon plant. The carbon plant is found at the Western part of the plant at about 2km west-ward away from location A.

The carbon plant is where the spant anodes are taken for cleansing and preparation for the next usage. Samples analyzed from this location where also high but in comparism to the pot room data's it's was not as high. This mean that activities in the carbon plant activities done there does not affect air quality as much as that of location A.

Gases are also emitted in this location but in a less concentration than that of the pot room (Location A).

The table 3 showing the representation of the air quality analysis gotten from the second location (carbon plant) and the maximum allowed concentration of these gases is shown in table 4 for comparism purpose.

**Table 4:** Showing the comparison table of the air quality result at location B and MAC by FEPA

Pollution/units of measurement	Maximum allowed concentration by FEPA	Air quality analysis in location A (Pot room)
Fluoride ((mg/m <sup>3</sup> )	0.033	0.0029
Aerosole (mg/m <sup>3</sup> )	1.5	0.000021
Carbonmonoxide (mg/m <sup>3</sup> )	66.5	66.5
Carbondioxide (mg/m <sup>3</sup> )	665	784.7
Sulphurdioxide (mg/m <sup>3</sup> )	5.32	4.9875
Nitrogendioxide (mg/m <sup>3</sup> )	6.65	4.3225

According to table 4, showing the graphical representation of location B (carbon plant) showed that carbonmonoxide was the same as the maximum allowed concentration in the atmosphere by the Federal environmental protection agency while carbondioxide exceeded it's maximum allowed concentration by 119.7mg/m<sup>3</sup>, this is as a result of the activities in the carbon plant which involves the usage of carbon for spant anode cleansing. Other gases where below their maximum allowed concentration (see table 4). The air quality of this area can also be considered polluted but not as polluted as the first location (pot room).

**Table 5:** Showing air quality in alscon location C (cast house)

Location	Distance from location	Volume of fluoride (mg/m <sup>3</sup> )	Volume of aerosole (mg/m <sup>3</sup> )	Volume of carbonmonoxide (mg/m <sup>3</sup> )	Volume of carbondioxide (mg/m <sup>3</sup> )	Volume of sulphurdioxide (mg/m <sup>3</sup> )	Volume of Nitrogenioioxide (mg/m <sup>3</sup> )
C <sub>1</sub>		0.0015	0.000003	99.75	545.3	6.517	7.049
C <sub>2</sub>		0.0008	0.000001	69.16	532	6.251	4.522
C <sub>3</sub>		0.0005	0.0000007	54.53	518.7	5.187	2.926
C <sub>4</sub>		0.0002	0.0000003	26.6	305.9	1.995	1.463
Total volume of Gases (EA)		0.003	0.0000023	250.04	1901.9	19.95	15.96
Average volume of gases (EA ÷ 4)		0.00075	0.00000058	62.51	475.475	4.9875	3.99

### Observation 3

In table 5 shows the third location where samples were collected is known as the cast house. This is where the molten metals is cast into ingot based on the specification of the company purchasing the ingot. This location is found at the Northern part of the plant. Analysis gotten from the samples collected from this location were much lower than that of location A (pot room) and not too far from analysis collected from location B (carbon plant).

Concentration of gases were considerable low; meaning that activities in this area does not affect air quality as that of location A (pot room) and location A (pot room) and location B (carbon plant).

Table 6 shows a comparative table, shows the graphical representation of table 6 below, between the maximum allowed concentration and the air quality analysis gotten from location C (cast house).

**Table 6:** Showing the comparism table of the air quality result at location C and MAC by FEPA

Pollution/units of measurement	Maximum allowed concentration by FEPA	Air quality analysis in location A (Pot room)
Fluoride ((mg/m <sup>3</sup> )	0.033	0.00075
Aerosole (mg/m <sup>3</sup> )	1.5	0.00000058
Carbonmonoxide (mg/m <sup>3</sup> )	66.5	66.51
Carbondioxide (mg/m <sup>3</sup> )	665	475.475
Sulphurdioxide (mg/m <sup>3</sup> )	5.32	4.988
Nitrogendioioxide (mg/m <sup>3</sup> )	6.65	3.99

Based on the table 6 in location C samples analyzed were lower than the maximum allowed concentration (MAC) though carbondioxide, carbonmonoxide and sulphurdioxide were quite close to their MAC.

Due to the fabrication of ingots and casting one will expect aerosole to be in high volume of concentration but the volume has been kept considerable low with little or no significant volume.

**Table 7:** Showing air quality in alson in location D (GATE)

Location	Distance from location	Volume of fluoride (mg/m <sup>3</sup> )	Volume of aerosole (mg/m <sup>3</sup> )	Volume of carbonmonoxide (mg/m <sup>3</sup> )	Volume of carbondioxide (mg/m <sup>3</sup> )	Volume of sulphurdioxide (mg/m <sup>3</sup> )	Volume of Nitrogenoioxide (mg/m <sup>3</sup> )
D <sub>1</sub>	500m	500m	0.0009	0.0000001	90.44	9.31	5.586
D <sub>2</sub>	800m	0.0006	0.000008	58.52	266	4.123	3.192
D <sub>3</sub>	1100m	0.0004	0.0000007	55.86	266	2.66	2.926
D <sub>4</sub>	1400m	0.0001	0.00000003	26.6	266.1	2.527	1.596
Total volume of Gases (EA)		0.002	0.0000018	228.76	1130.62	18.62	13.3
Average volume of gases (EA ÷ 4)		0.005	0.00000045	57.19	283.29	4.655	3.325

#### Observation 4

Samples collected from this area were very low and yielded the lowest analysis in the laboratory. This may be due to the fact that this location is the eastern part of the company which is close to the gate and administrative block. There are no aluminium production activities going on around this area but due to diffusion pollutants were still found in the samples gotten from this area in a low concentration.

Table 8 shows the comparison between the maximum allowed concentration and the air quality analysis of location D.

**Table 8:** showing the comparism table of the air quality results at location d and mac by fepa location d

Pollution/units of	Maximum allowed concentration by FEPA	Air quality analysis in location A
Fluoride ((mg/m <sup>3</sup> )	0.033	0.0005
Aerosole (mg/m <sup>3</sup> )	1.5	0.00000043
Carbonmonoxide (mg/m <sup>3</sup> )	66.5	57.19
Carbondioxide (mg/m <sup>3</sup> )	665	283.29
Sulphurdioxide (mg/m <sup>3</sup> )	5.32	4.655
Nitrogendioxide (mg/m <sup>3</sup> )	6.65	3.325

This is the lowest volume of pollutant gotten throughout this exercise obviously due to the fact that aluminium activities are not done on this area. Though traces of gases were still found and this can be because of the nature of air as a moving gas, therefore making all the environment around the plant polluted.

#### 5. Cumulative interpretation of result

This involves the final interpretation of result gotten from the air quality analysis done in Aluminium Smelter Company of Ikot Abasi Local Government Area. The cumulative interpretation of results refers to the general compilation of the volume of gases emitted into the environment around the aluminium smelting plant. This is done to assess the level of pollution by the company.

Results gotten from location A, B, C and D as shown in table 1, 4.13, 5 and 7 respectively were added and their average gotten as the final value of the air quality analysis of the plant environment. This value will also be compared with the maximum allowed concentration by the Federal Environmental Protection Agency (FEPA) of 2005. This will answer the research question, as shown in table 4.2.1.

## 6. Conclusion

From the foregoing it can be seen that air quality analysis is an important part of aluminium production process that demands attention from both the aluminium smelting company, the community and the environmental protection agency. This is because, if air quality is neglected the level of damage it will pose to the environment and the health of the people in the aluminium producing area cannot be over emphasized. Therefore, there is a need to protect both the workers and resident of the aluminium producing area.

A sound air quality monitoring team is very essential for sustainable development of the environment and economic growth for the aluminium company. Hence, the target of the air quality monitoring team is to curtail the extent of air pollution is aluminium smelting companies to eschew environmental pollution.

## References

- Brower H. (2010). Aluminium and its importance. London, Heinemann.  
Federal Environmental Protection Agency (FEPA) (2010). Volume of gases in the air.  
International Aluminium Institute (2009). Anode effect and compound emission survey.  
Smith, J. K. (2009). The effect of exposed fluoride (A critical review in fluoride) *Achieves of Biology*, Vol. 3, No. 33:543-546.  
World Bank (2001).

